CAPNOGRAPHY IN THE EMERGENCY DEPARTMENT: A REVIEW OF USES, WAVEFORMS, AND LIMITATIONS

Brit Long, MD,* Alex Koyfman, MD,† and Michael A. Vivirito, RN, CEN‡

*Department of Emergency Medicine, San Antonio Military Medical Center, Fort Sam Houston, Texas, †Department of Emergency Medicine, The University of Texas Southwestern Medical Center, Dallas, Texas, and ‡Department of Emergency Medicine, Joint Base Elmendorf-Richardson Medical Center, Joint Base Elmendorf-Richardson, Alaska

Abstract—Background: Capnography has many uses in the emergency department (ED) and critical care setting, most commonly cardiac arrest and procedural sedation. Objective of the Review: This review evaluates several indications concerning capnography beyond cardiac arrest and procedural sedation in the ED, as well as limitations and specific waveforms. Discussion: Capnography includes the noninvasive measurement of CO2, providing information on ventilation, perfusion, and metabolism in intubated and spontaneously breathing patients. Since the 1990s, capnography has been utilized extensively for cardiac arrest and procedural sedation. Qualitative capnography includes a colorimetric device, changing color on the amount of CO2 present. Quantitative capnography provides a numeric value (end-tidal CO2), and capnography most commonly includes a waveform as a function of time. Conditions in which capnography is informative include cardiac arrest, procedural sedation, mechanically ventilated patients, and patients with metabolic acidemia. Patients with seizure, trauma, and respiratory conditions, such as pulmonary embolism and obstructive airway disease, can benefit from capnography, but further study is needed. Limitations include use of capnography in conditions with mixed pathophysiology, patients with low tidal volumes, and equipment malfunction. Capnography should be used in conjunction with clinical assessment. Conclusions: Capnography demonstrates benefit in cardiac arrest, procedural sedation, mechanically ventilated patients, and patients with metabolic acidemia. Further study is required in patients with seizure, trauma, and respiratory conditions. It should only be used in conjunction with other patient factors and clinical assessment. Published by Elsevier Inc.

Keywords—capnography; capnometer; carbon dioxide; end-tidal; monitoring; resuscitation; waveform

INTRODUCTION

Breathing consists of oxygenation and ventilation. Oxygenation can be assessed with pulse oximetry, while capnography provides information on ventilation (effectiveness of carbon dioxide [CO2] elimination), perfusion (CO2 transportation in vasculature), and metabolism (production of CO2 via cellular metabolism) (1−8).

Capnography includes the noninvasive measurement of CO2 partial pressure during the breathing cycle. Capnography and capnometry are often used interchangeably, though they are distinct entities. Capnography is a comprehensive measurement and display of CO2, including end-tidal and inspired CO2 as a number and waveform. A capnometer displays a numeric value for CO2 on a monitor. The CO2 waveform is most commonly displayed as a function of time, though critical care uses include graphs with the waveform as a function of volume (1−8). One of the first studies utilizing exhaled CO2 was conducted in the 1970s (9). Since the 1990s, capnography has been used for an increasing
number of conditions, procedures, and monitoring (1–4,8).
The concentration of CO₂ vs. time represents the CO₂ waveform, and changes in this shape can assist physicians in a variety of conditions, including assessment of disease severity, cardiac arrest (compression quality, return of spontaneous circulation, endotracheal tube placement, prognosis, among others), procedural sedation, and critical illness (1–4,7,8).

Capnography measures CO₂ partial pressure by mainstream or side-stream device. Mainstream devices measure CO₂ directly from the airway, most commonly with the sensor housed directly in the respiratory circuit, and these devices are used for intubated and spontaneously breathing patients. Sidestream devices measure CO₂ by sampling exhaled breath through a side port and can be used for intubated and spontaneously breathing patients as well (2–4,8,10,11).

Qualitative monitors include a colorimetric end-tidal CO₂ (EtCO₂) device, which changes color depending on amount of CO₂ present (8,10,11). This color change occurs due to the pH of carbonic acid that is formed as a product of the reaction between carbon dioxide and water. The device is purple for EtCO₂ < 3–4 mm Hg (< 0.5%), tan for 3–15 mm Hg (0.5%–2%), and yellow for values > 15 mm Hg (> 2%) (1–4,8,10,11). Quantitative monitors utilize infrared radiation, as CO₂ absorbs a specific wavelength of radiation, allowing photodetectors to calculate CO₂ concentration in the sample (2–4,8–11).

A capnogram consists of two primary components, inspiratory and expiratory, which can be further broken into four different phases (2–4,8–11). This is demonstrated in Table 1, with Figure 1 displaying a normal waveform.

Interpretation requires consideration of three aspects of capnography: the EtCO₂ maximum number or plateau, the shape of the capnogram, and the difference or gradient between EtCO₂ and arterial CO₂ pressure (6–8,10,11). Normal ventilation and lung function demonstrate a rectangular waveform. Factors that affect capnography include CO₂ production, CO₂ transport, ventilation, and ventilation to perfusion ratio changes. Ventilator settings and malfunctions, disconnections and leaks, and monitor malfunctions can also affect capnography readings. The maximum PCO₂ at end expiration is the EtCO₂, which varies normally between 35 and 40 mm Hg. The gradient between arterial CO₂ and alveolar CO₂ is approximately 3–5 mm Hg in healthy patients, due to the combination of dead space CO₂ and alveolar CO₂ (1–5,8,10,11). This gradient functions as a surrogate for assessing ventilation–perfusion relationship (1–5,8,10,11).

### METHODS

The authors conducted a literature search of Medline, EBSCO, and Google Scholar for search terms including capnography, capnogram, interpretation, cardiac arrest, procedural sedation, end-tidal, return of spontaneous circulation, trauma, injury, metabolic acidosis/acidemia, critical illness, pulmonary embolism, seizure, sepsis, and obstructive airway disease. Studies were limited to those evaluating human subjects in English from 1980 to 2017. The authors agreed on articles to include by consensus. This review is not a systematic review or meta-analysis, and study quality was not assessed formally with a standardized tool.

![Figure 1. Normal capnography waveform. Reprinted from: http://www.capnography.com/new/encyclopedia, with permission.](http://www.capnography.com/new/encyclopedia)

Download Persian Version:

https://daneshyari.com/article/8719728